Effect of Aluminium Oxide Filler Composition on Thermoplastic Polymer

Akash Jayanthan, Raghavendra Ravi Kiran K, Y. P. Deepthi

Abstract*: Polymers are being used in many industrial applications. Among them PTFE is very popular as it is a self-lubricating material. In this work it is combined in different percentages of weight with alumina (0,5,10,15,20). Samples were prepared by powder metallurgy technique. Wear tests were performed for various loads of 20,30,40 N with varying percentages of reinforcement and at two speeds of 170rpm and 190 rpm. Shore D hardness was measured for different samples. From the experimentation it was found that less wear volume and friction force was registered at 15% and 20% reinforced composites respectively, whereas high toughness was observed at 15% reinforcement.

***Keywords* : PTFE, powder metallurgy, reinforcement, toughness.**

I. INTRODUCTION

For many years bearing materials have been an interesting area for research. Conventional materials which were used for bearing manufacturing are now getting replaced with many novel materials. Among which polymer composites is also most appealable because of its unique properties and reasonably economical compared to conventional bearing steels. Polytetrafluroethylene (PTFE) is widely used thermoplastic polymer. PTFE has unique properties like low coefficient of friction, corrosion resistant,self lubricant which makes it suitable for sliding applications[1-3]. As PTFE is hydrophobic in nature, it can be an alternate material when it needs to be operated for corrosion resistant environment like water. Yet PTFE has certain limitations like low wear resistance, which does not permit for sealing application[4-6]. This limitation can be improved by filling it with metallic or nonmetallic fillers [7-8].Many researchers work was related on conventional fillers like carbon fibers, glass fibers, graphite etc. Moreover there is a need to look for unconventional fillers which can cater the growing demands of decreasing wear rate. Tanaka et al. found out that filler size and shape of filler also contribute tribological properties[9]. They have worked on fillers of various shapes and sizes, which concludes the presence of variation in tribological behavior.

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Alumina is a popular choice as filler for PTFE material. Strong compressive strength (2,000 to 4,000 MPa), low density, strong gliding properties, strong resistance to corrosion and wear, high hardness, mild thermal conductivity are the reasons behind this. Aluminum is highly sensitive and when exposed to atmospheric oxygen it forms a thin layer of aluminum oxide. This surface protects against further corrosion of the metal. Using Anodizing process a thin layer of oxide is deposited to enhance the properties of substrate. A proportion of aluminium in the alloys like bronze is used to increase corrosion resistance.

Researchers [10-14] during their experimentation noticed the wear resistance improvement in PTFE composite filled with alumina of size 38 nm compared to PTFE polymer. He mentioned the value to be 600 times more compared to pure PTFE. By adding alumina to PTFE polymer the mechanical and tribological properties were observed. An attempt was made to find the alternate material for bearings based on tribological and toughness properties.

II. EXPERIMENTATION

The tribological properties were measured by pin on disc tribometer. PTFE required for experimentation was procured from modoplast company ltd. Alumina of size was purchased from Thomas Bakers Pvt ltd company. PTFE and Alumina both in powder form are blended together to produce composite material. Alumina of wt% of 5,10, 15,20 are added to PTFE. The compaction of the samples was followed by the sintering method [14-16].Powder Compaction is the method by applying high loads to compress a product powder in a die. The devices are typically held vertically with the punch tool surrounding the cavity's edge. The powder is then compacted and then pushed out of the die cavity. This process is economical as the product obtained needs minute work to be done for its use in various applications.

Polymers fuse at room temperature only hence cold pressing is used. In this work a Universal Testing Machine is used to apply load for compaction. The load used are 50 KN. After 50 KN crack formation was observed to the specimen. The die used is a cylindrical shaped one made of medium carbon steel coated with carbide at interfaces. It has a Plunger, stopper and hollow cylindrical shape of diameter 10mm.

Once after compaction the specimens are sintered using a muffle furnace. For a long time, the samples are put under high heat. Bonding between the porous aggregate particles takes place under heat and as sample gets cooled it forms a solid component.

Fig.1 Die used for compaction

III. EXPERIMENTAL RESULTS AND DISCUSSION

Hardness

The composite specimens were in accordance to ASTM D2240. Shore type Durometer has been used for hardness testing. The tip calculating the hardness has a 1.1 mm – 1.4 mm diameter hardened steel rod with a conical point of 30 °, 0.1 mm radius tip. The polymers have a property called resilience which makes it different from the metals. Due to this property they cannot be used in Brinell or Rockwell hardness testers for measuring the hardness since the values are incorrect. Hence Shore D test is preferred for measuring hardness. A load of 10 N is applied for about 15 seconds for taking one reading for hardness. Multiple readings are considered for the accurate value of hardness.

Fig.2: Universal Testing Machine

Fig.3 Shore Durometer

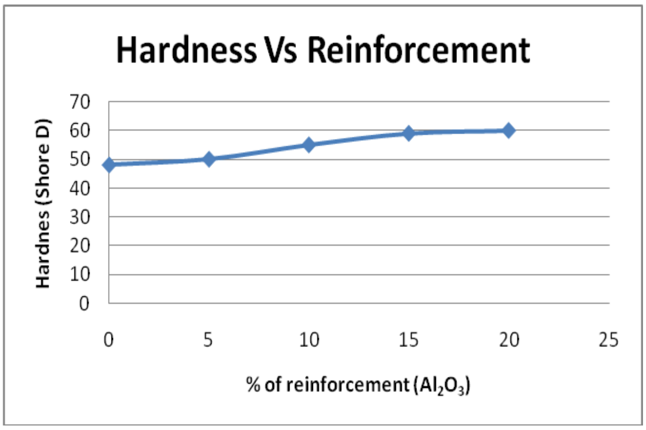

Fig 4: Shore D hardness

It can be inferred from the graph that the highest value of hardness was recorded for the 20% composition and lowest value was for pure PTFE composition. As Alumina is a soft material with the addition of it to the PTFE increases the hardness. Hence the strength will be higher for the specimens with the increase in percentage of Al_2O_3 to the composite.

IV. WEAR AND FRICTION

The tribological properties were evaluated using pin-on-disc tribometer. A pin on Disc tribometer consist of rotating disc and a fixture that can hold specimen. The specimen gets in contact with disc on application of load. Linear variable differential transducer (LVDT) mounted on the machine that helps in recording the height loss and frictional force.

The sample were made to a dimensions ϕ10x20 mm height, whereas the disc was of material high carbon EN31 steel with HRC 60 hardness. Dry-sliding wear testing was performed using a PC assisted pin-on-disk wear-testing machine at 170 and 190 rpm for 20-40 N average while maintaining a sliding distance of 2000 m and 120 mm track width. Wear checks are carried out in conjunction with the standard ASTM G99.

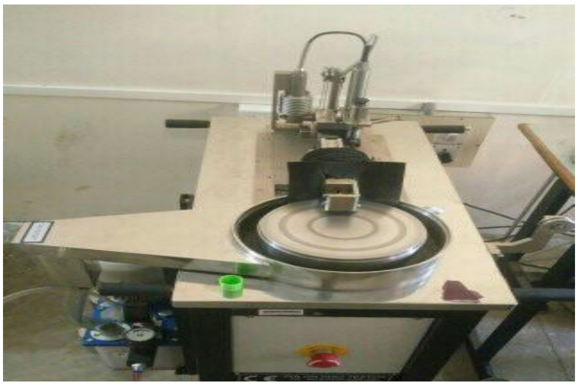

Fig. 5 Wear Testing Machine

Table 1: Details of factor considered and levels

Factor Code	Factor	Number of Levels	Different Levels
A	Composition (Weight %)	5	0, 5, 10, 15,20
B	Speed (rpm)	2	170, 190
C	Load(N)	3	20, 30,40

Line plots of wear:WEAR RESULTS for 170 rpm

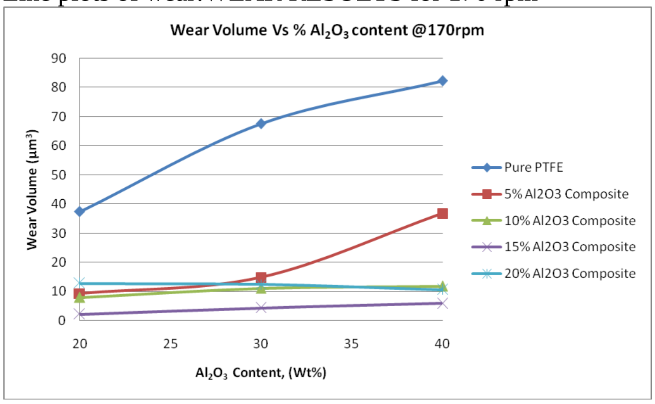

Fig.6 Wear Plot for 170 rpm

The graphs show the wear values for 170 and 190 rpm for different compositions of reinforcement. The highest value was recorded for pure PTFE for 40N load and the least value was recorded for 15% composition for 20N load.

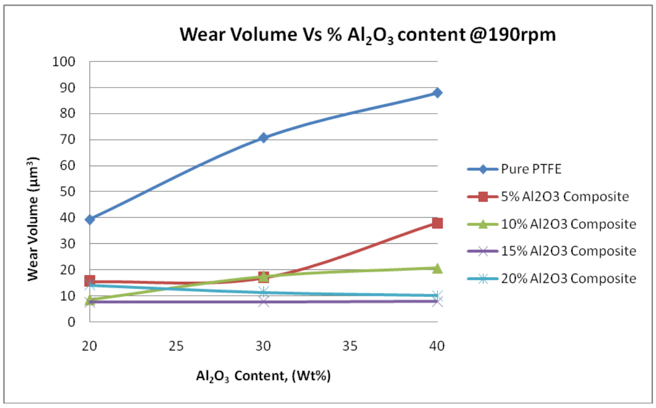

Fig.7 Wear Plot for 190 rpm

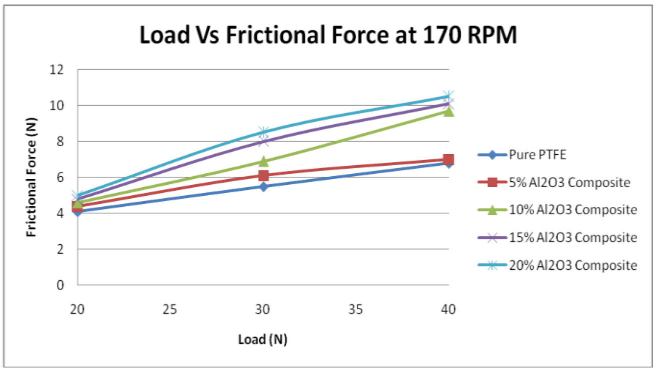

Fig.8 Load Vs Frictional force at 170rpm

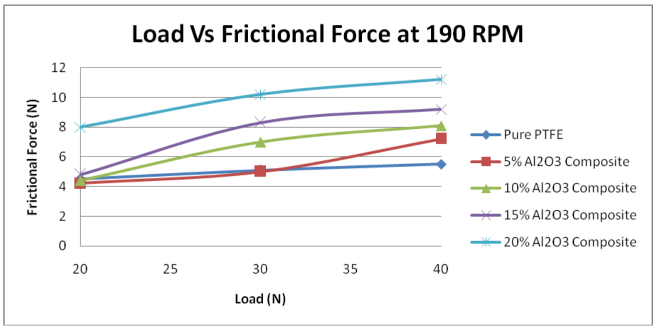

Fig.9 Load Vs Frictional force at 190rpm

The fig. 8 and fig. 9 the shows dependency of frictional force on load for varying filler contents at 170 and190rpm respectively. As the load rises, there is an increase in frictional force which may be observed.

V. CONCLUSIONS

Adding Al_2O_3 as a filler to PTFE has been shown to be an effective technique for increasing the composite's wear resistance. It can be found from the experimental work on PTFE and Al_2O_3 composite that as the percentage of reinforcement increases, the material's hardness increases as well. From the experimentation, it was observed that the reinforcement of 15% composite has least wear value (microns) and as we increase the reinforcement from 0% to 15%.Beyond 15% of the reinforcement addition to PTFE showed increase in wear rate. Also it can be concluded that as the surface contact area increases with increase in load, thereby enhances frictional force. The composite filled with 20% alumina exhibited lower frictional force compared to other compositions.

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